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Los Alamos National Laboratory:

21st Century Solutions to Urgent National Challenges

Challenges confronting society are increasingly complex, interdependent, and global. Policymakers recognize that their decisions impact global stability, economics, and the environment. Decisions made today will impact the Nation and the world for decades to come. We must harness science and technology to provide innovative solutions, and insights into the interconnections involved in making choices that affect such complex systems.

Los Alamos National Laboratory has been called upon to meet urgent national challenges for more than 65 years. The people, tools, and technologies at Los Alamos are a world class resource that has proved decisive through our history, and are needed in the future. We offer expertise in nearly every science, technology, and engineering discipline, a unique integrated capability for large-scale computing and experimentation, and the proven ability to deliver solutions involving the most complex and difficult technical systems.

This white paper outlines some emerging challenges and why the nation needs Los Alamos, the premier National Security Science Laboratory, to meet these challenges.

Complex systems, global security challenges

Twenty-first century security challenges are multi-polar and asymmetric. A few nations have substantial nuclear arsenals and active nuclear weapons programs that still threaten vital US national security directly or by supporting proliferation. Maintaining a credible US nuclear deterrent and containing further proliferation will continue to be critical to US national security. Overlaid against this security backdrop, the rising worldwide population and its effects on global climate, food, and energy resources are greatly complicating the degree and number of security challenges before policy makers.

Climate-Energy Link: Global climate changes influence future energy choices. The prospect of global climate change driven by fossil fuels has sparked a global discussion on measures to curb greenhouse gas emission. This discussion must be guided by the best science, and Los Alamos is recognized as a leader in global climate modeling and monitoring. Implementing any global climate treaty will require the nation's best technology, including filling key knowledge gaps:

- understanding the global carbon cycle, and
- monitoring the global carbon budget from natural and man-made emissions.

Data from these gaps are required to verify that all nations are meeting treaty commitments. The immense challenge of monitoring global carbon emissions and ensuring compliance is similar to the multi-national Vela Program to monitor compliance with the comprehensive nuclear test-ban treaty using ground- and space-based measurements and innovative data-acquisition techniques and models. Los Alamos played a leading role in developing and implementing technology for the Vela Program, which began in 1959 and created a worldwide framework that continues today.

Global Energy Demand Growth: The need for energy diversity. The US must develop new energy sources to ensure its energy security as the worldwide demand for energy doubles within a generation. Today, renewable energy sources supply less than 3% of our total; growing this will require technology breakthroughs in generation, transmission, and energy storage. Next-generation nuclear energy must be developed as a global enterprise if it is to benefit developing nations without increasing proliferation of nuclear weapons. Los Alamos is a leader in the materials and chemistry needed to grow these carbon-free sources.

Energy choices impact global markets and our financial, energy, electrical, and transportation infrastructure. For example, no current computer models can accurately evaluate the tradeoffs between a treaty capping greenhouse gas emissions and incentives to rapidly grow a carbon-neutral energy supply. We need decision analysis tools, like those developed at Los Alamos, that can describe our complex, interdependent system at an appropriate level of integration and complexity and provide rapid insights at regional, national, and global scales on long-term consequences.

Accelerating Global Threats: Rapid adaptation of information and technology could harm the US. The accelerated pace of research and technology development and nearly instantaneous access to information on the Web requires that we anticipate new threats and rapidly deliver solutions. Los Alamos' science and technology expertise is applied broadly today to detect and protect against new threats (such as improvised explosive devices, liquid explosives, weapons of mass destruction, and cyber attacks from individuals and states). Nearly every beneficial technology can and will be applied by adversaries in ways that threaten our security; e.g., as computer-processing power grows exponentially, so does the cost and incidence of cybercrime.

Los Alamos has demonstrated a cycle of innovation where we have developed world-leading capabilities and facilities in response to urgent, unique missions. While delivering outstanding results for our core programs, we also spin out new discoveries that lead to new missions. This innovative cycle has been fueled for the last 15 years by the stockpile stewardship program.

Stockpile Stewardship

The US manufactured its last nuclear weapon in 1989 and halted underground nuclear testing in 1992, thereby creating an unprecedented scientific and engineering challenge: how to maintain the safety, security, and reliability of the nuclear deterrent without testing. In response, the scientists and engineers of Los Alamos and other national labs developed a new approach to predictive science. This science-based program of experimentation, improved diagnostics, and greatly increased computational capabilities gave us the tools to assess and redress the needs of the stockpile. New experimental facilities for scientific discovery research that strengthens understanding of the physics of weapons performance contributed to the program's remarkable success. A number of technical issues in the stockpile have been resolved; several warhead types are undergoing life extensions; and, for 13 years, Laboratory directors have certified to the

President that the stockpile is safe, reliable, and there is no need for nuclear testing. Stockpile stewardship also allowed the US to reduce its stockpile to the lowest level since the Eisenhower Administration.

Exemplary Los Alamos Innovations Benefiting Society

Angel Fire: TiVo for the Troops. This rapid-response video system integrates the most advanced digital image processing and engineering to save the lives of troops and civilians in Iraq. It was developed and fielded in less than 18 months with the Air Force Research lab and the U.S. Marine Corps.

Preventing a pandemic: Los Alamos simulations allow prediction and intervention to prevent the spread of pandemic disease. Using detailed computer models for how disease is spread, including data for where people live, work, attend school and travel, we can simulate the effectiveness of intervention strategies such as vaccine distribution, and also assess the human and economic cost. The codes have been used by the Centers for Disease control and industry to mitigate vulnerabilities to pandemic disease.

Keeping Tabs on the Rogues: Los Alamos provided a definitive interpretation of the recent North Korea nuclear weapons test to distinguish between natural and man-made events. Los Alamos was the only laboratory providing technical support to the 6 party talks.

PowerFactoRE: Flexible tool for predicting reliability in a complex manufacturing environment saves Procter & Gamble over **$2 billion**. This software tool was adapted from weapons reliability software, and the collaboration provided real-world data that strengthened the predictive value of the software for the stockpile stewardship program.

Improve Airliner safety--Radiation toughness testing: Airplane safety relies on testing at the Los Alamos Neutron Science Center (LANSCE) for radiation resistance of electronics. One hour of radiation testing at LANSCE approximates 100 years of aircraft altitude testing, and virtually every semiconductor company uses the facility to study the robustness of their devices.

Environmental cleanup faster and cheaper: Los Alamos expertise in actinide chemistry enabled Rocky Flats cleanup 1 year ahead of schedule at a savings of **$1 Billion**. Los Alamos scientists determined the chemical form of plutonium in the soils and concretes at the Rocky Flats site. This work proved that the primary risk was erosion of plutonium in soil, rather than in the ground water, and changed the clean-up strategy.

Medical imaging and cancer treatment: Los Alamos provides the calibration isotope that is used in every PET scanner in clinical use. The customer base includes over 250 hospitals and research centers across the Nation.

Flow cytometry: the technology for blood typing in clinical use worldwide was first developed at Los Alamos. The NIH National Flow Cytometry Resource, housed at Los Alamos for 27 years, has spawned 6 R&D100 awards, most recently for acoustic

focusing, a technology allowing field-portable instruments for bio-analysis outside the clinic.

Climate modeling: Los Alamos runs two of the four codes used by the Intergovernmental Panel on Climate Change, the recipient of the 2007 Nobel Peace Prize. The coupled sea-ice model and the ocean circulation model capture the natural systems that have a strongly influence climate change and carbon dioxide concentration. Our ability to model ocean temperature, currents, and chemistry worldwide has led to the first resolution of the vortices in major ocean currents that drive regional weather patterns.

Fueling the future: hydrogen research. The polymer-electrolyte membrane fuel cell first developed at Los Alamos forms the basis for the current fuel cell industry, including automotive fuel cells that will hit the market by 2010. The DOE Center of Excellence in Chemical Hydrogen storage at Los Alamos aims at solving one of the key barriers to use of hydrogen as a transportation fuel: the ability to safely store energy in chemical bonds using hydrogen.

Quantum Dots: Nanomaterials enabling solar energy. The Los Alamos discovery of carrier multiplication, where more than one electron can be generated for each photon absorbed, is an example of the kind of science breakthrough needed to allow solar energy generation with dramatically improved efficiency.